Chapter 7

MEASUREMENT AND EARTHWORK CALCULATIONS

Introduction

An important part of the discussion of earthwork is the determination of pay quantities. In this section the following will be discussed:

* Contract quantity payment.
* Measured quantity including:
    * Cross sections.
    * Computations of volumes.
    * Terms.

Contract Quantity Payment

According to the Standard Specifications, the quantities of excavation shown in the contract will be paid, unless either the Contractor or INDOT disagrees. When paying plan quantities for excavation, the following procedures are to be followed:

* New original cross-sections are to be taken at 500 foot intervals and plotted to check the accuracy of the original sections.
* Final cross-sections are to be taken at 500 foot intervals. Cross-sections should be complete sections in cuts and from the shoulder break to the R/W in fills. These final sections should indicate substantial conformance with the planned cut slopes and ditches, and will be used to determine if earthwork deductions are required.
* Spot checks will be made of the cross-section areas shown in the plans. The number of spot checks should average one for each 2,000 feet with the locations concentrated in areas of the major excavation. Additional area checks should be made to determine whether the plan quantity needs to be adjusted for areas varying more than 10% from the area shown of the plans. If the average deviation of all the areas checked varies from the planned areas at the corresponding locations by more than 2%, a more detailed check will be required on those areas or balances showing the highest deviation.
* The computation of the volume from the planned areas of one balance should be checked. In general, this should be the largest balance in the contract. Any other questionable balances should be checked for volume computations.
* Any other pertinent facts which would justify using plan quantity or indicating the need for adjustments should be considered.

Measured Quantity Payment

Where measured quantities are specified or found necessary by the check of plan quantities, the

excavated quantities in each balance will be computed on Form IC-401. If "excess cut" or "waste" deductions, as described later, are applicable to the roadway excavation, they will be deducted from the balance totals.

Measurement and Earthwork Calculations Section 203.27

Payment for grade construction is usually based on a bid price per cubic yard for excavation measured in place as computed from survey notes. The unit price generally includes the following:

* Hauling excavated material (cut) from within the limits of the roadway or bringing in other material from outside areas(borrow).
* Building the embankments (fill) to specified form.
* Disposing of surplus material (waste).
* Performing such operations as forming earth shoulders, trimming slopes, and preparing the subgrade for pavement.

Cross-Sections

The determination of earthwork quantities is based upon field cross-sections taken in a specified manner before and after excavation. A complete discussion of cross-sections will be given in the Construction Procedures 1 course of the Certified Technician Program.

Cross-sections are vertical profiles taken at right angles to the survey centerline. Every section is an area formed by the subgrade, the sideslopes, and the original ground surface.

Volumes

Volumes will be computed from cross-section measurements by the average end area method.

$$\text{Volume (metric)} \quad \text{(cu. meters)} = \left[L \times \frac{(A1 + A2)}{2}\right]$$

* L is in meters. A1 and A2 are in square meters.

$$\text{Volume (english)} \quad \text{(cu. yds.)} = \left[L \times \frac{(A1 + A2)}{(2 \times 27)}\right]$$

* L is in feet. A1 and A2 are in square feet.

It is important to use this formula to compute earthwork quantities because the specifications require it. All the plans and bidding for the project have been completed using this method.

The formula for average end areas is accurate only when the end areas are equal. For other cases, it generally gives volumes slightly larger than their true values. If it were applied to a pyramid, for example, the error would be the maximum and would be equal to 50% of the correct volume. In practice

however, the total error over the long run is seldom more than 2%.

Also, where it is impractical to measure material by the cross-section method due to erratic location of isolated deposits, acceptable methods involving three dimensional measurements may be used to measure material in its original position.

$$\text{Volume (cu. meters)} = \text{Length} \times \text{Width} \times \text{Depth}$$

$$\text{Volume (cys)} = \frac{\text{Length} \times \text{Width} \times \text{Depth}}{27}$$

Earthwork may also be measured on a linear basis. For linear grading items in a contract, the measurement for payment will be based on the actual length of roadway mileage constructed. This includes all classes of excavation on both sides of the roadway.

Excavation items may also be measured on a weight basis. Refer to Section 203.27

Embankment fills are not paid for directly. The cost is to be included in the other pay items of the contract. In certain contracts it will specify to pay for fills directly.

Borrow will be measured and paid for by the cubic yard. In most cases, borrow will be cross-sectioned in its original position before excavation begins, and after excavation is completed. The volumes will be computed by the average end area method.

Excavation may also be measured on a lump sum basis. When this occurs, no individual measurements will be required.

There are many other special cases for different types of measurements and classes of excavation which may be encountered on a construction contract. The plans, special provisions, Standard Specifications, General Instructions To Field Employees, and your PE/PS are all useful tools to be used when starting an operation on a contract.□